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(54) Phase separation device

(57) A device for separating the phases of a mixture containing at least two phases comprises a vessel containing at least one pack of plates 13 through which the mixture flows horizontally, the or each pack comprising a plurality of layers of plates, with the plates in each layer being parallel and laterally inclined (Fig. 2 shows a vertical section, and flow is perpendicular to the plane of the drawing). In an oil-water separator the plates are followed, in the flow direction, by a coalescer pad and respective outlets for separated phases.

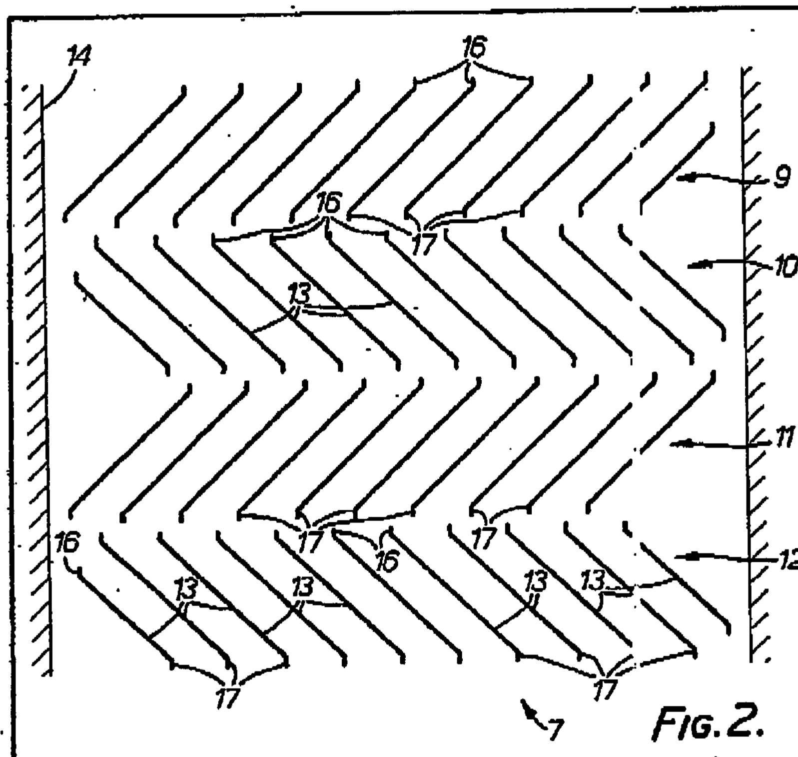

FIG. 2.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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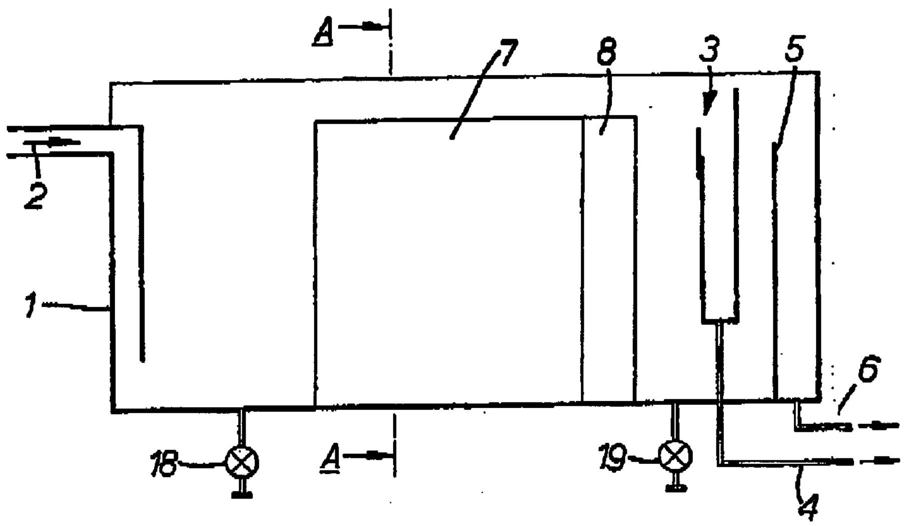

FIG. 1.

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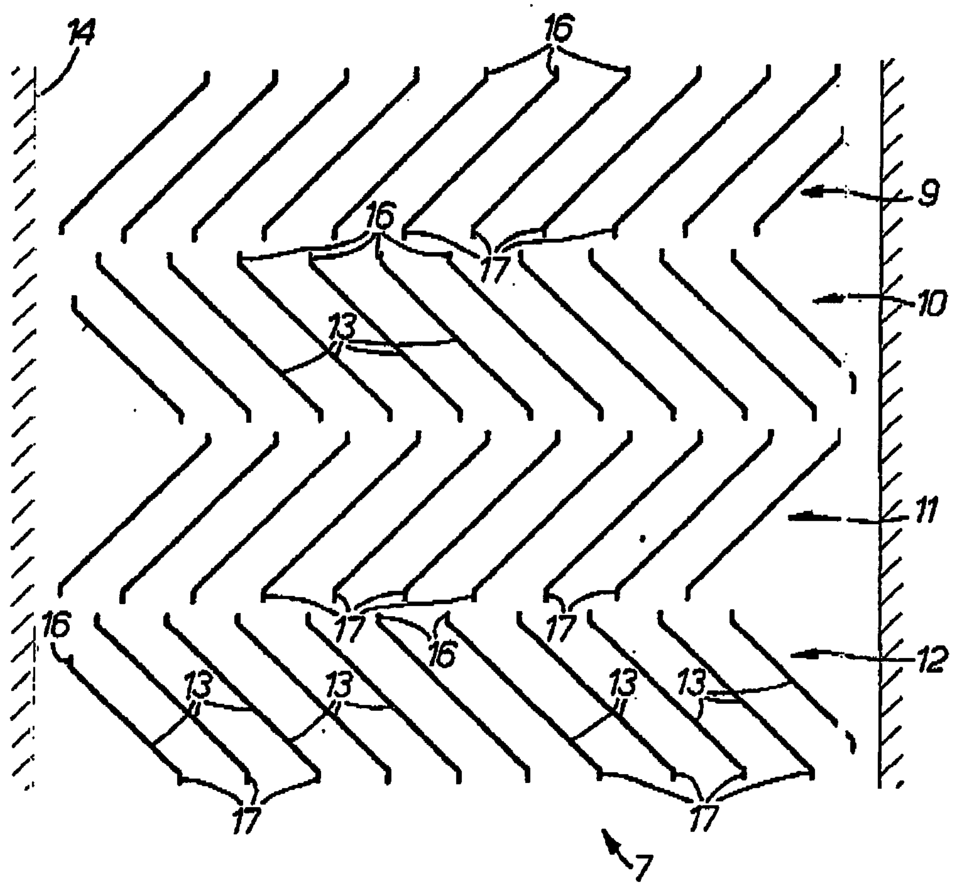

FIG. 2.

SPECIFICATION
Phase separation device

This invention relates to a phase separation device for separating the phases of phase mixture comprising at least two phases.

A problem frequently encountered in chemical engineering is the separation of phase mixtures of various kinds, for example liquid-liquid dispersions, gas-liquid dispersions (i.e. foam or mists), solid-liquid dispersions, gas-solid dispersions (smokes), and more complex three phase dispersions, e.g. gas-liquid-liquid, solid-liquid-liquid, and gas-liquid-solid dispersions. Commonly adopted types of apparatus include so-called plate or shelf settlers, as well as simple "empty vessel" separators in which the phase mixture is allowed to settle under gravity under conditions of very low overall flow velocity.

Plate separators generally use flat or corrugated plates. Such plates may be fixed with constant, uniform separation, or in one known design, a sinusoidally varying plate separation may be adopted. The plates may be horizontal or inclined in the direction of flow.

In those separators in which the plate separation is not constant the purpose is to promote alternate acceleration and deceleration, i.e. an increase and a decrease in local pressure, of the fluid mixture. This is said to promote droplet coalescence in the mixture and thereby to improve separation. However, to achieve this end it is necessary to position the plates close together and to make the change in plate separation over each interval as large as possible. The disadvantage of this is that the plate pack is then subject to blockage if solid particles are present. As, in practice, may liquid-liquid dispersions, particularly liquid effluents, tend to contain at least a certain proportion of solids, the design of such separators is not entirely satisfactory.

In the majority of plate separators with uniform plate separation the plates are inclined in the direction of flow. In the case of separators designed for liquid-liquid dispersion separation, e.g. oily water separation, the plates are tilted so that the coalesced lighter phase (oil) that collects on the underside of each plate flows in counter current to the aqeous phase. In the case of solids/liquid separation co-current flow will occur in such an arrangement, provided that the solids are heavier than the liquid. By changing the inclination a co-current, counter-current arrangement can be achieved.

A design has also been proposed, the so-called cross-flow design, in which a set of uniformly spaced plates is used which are generally aligned with the direction of flow but are inclined transverse to this direction. Although this design gives rise to no particular serious problem relating to liquid level on interface control, its separation power is not entirely satisfactory.

The present invention accordingly seeks to provide a phase separation device which exhibits improved separation characteristics compared with inclined plate separators and with existing cross-flow separators. It further seeks to provide an improved phase separation device which is not prone to ready blockage by solids. The invention also seeks to provide a novel form of separator which enables a coalescer to be incorporated into the design in a particularly compact manner.

According to the present invention there is provided a phase separation device for separating the phases of a phase mixture containing at least two phases, which device comprises a vessel containing at least one pack of lamellar bodies through which phase mixture is passed in use, the or each pack comprising a plurality of layers of lamellar bodies arranged one above the other in the path of flow of the phase mixture and each layer comprising a plurality of lamellar bodies arranged substantially parallel to one another and inclined transverse to and substantially aligned with the direction of flow of the phase mixture.

According to another aspect of the present invention there is provided a process for separating the phases of a phase mixture containing at least two phases, which comprises passing the mixture through a vessel containing at least one pack of lamellar bodies, the or each pack comprising a plurality of layers of lamellar bodies arranged one above the other in the path of the flow of the phase mixture and each layer comprising a plurality of lamellar bodies arranged substantially parallel to one another and inclined transverse to and substantially aligned with the direction of flow of the phase mixture, and recovering at least one separated phase from the downstream end of the vessel.

The invention thus envisages a multi-layer cross-flow type coalescer. Compared with a single layer cross-flow arrangement the device of the present invention has a markedly improved separation efficiency.

The device of the invention is preferably designed so that the direction of flow of the phase mixture is substantially horizontal or at an angle of at most not more than about 15° to the horizontal.

Typically the phase mixture comprises an oil-in-water or water-in-oil type dispersion. Such dispersions may include "primary dispersion" sized droplets, i.e. droplets of dispersed phase which will upon standing under gravity settle out into a layer of disengaged phase, and possibly also "secondary dispersion" sized droplets, i.e. droplets that are too small to settle out solely under the influence of gravity. Typically droplets having a diameter of about 100 micrometres or more can be classed as "primary dispersion" sized droplets, whereas droplets with a diameter of less than about 20 micrometres are classed as "secondary dispersion" sized droplets.

The device of the present invention is aimed at effecting disengagement of dispersions with "primary dispersion" sized droplets; if, however, the dispersion contains or may contain also "secondary dispersion" sized droplets, then it will

usually be desirable to incorporate in the device a coalescer means, such as a pad of knitted mesh fabric, downstream from the pack or packs of lamellar bodies. The lameller bodies are preferably uniformly spaced one from another within each layer and/or pack.

In a particularly preferred design the upper edges of the lamellar bodies of one layer lie intermediate to the lower edges of the lamellar bodies of the layer immediately above the first mentioned laver and the plates of adjacent layers are inclined in opposite transverse directions.

The lamellar bodies within each layer are all substantially parallel to each other and the angle between the plane of each lamellar body of a respective layer and a vertical plane, measured in a plane at right angles to the direction of flow, may be, for example, from about 30° to about 60°, typically about 45°. Hence, when the direction of flow is horizontal, the lamellar bodies may be inclined at an angle to the horizontal of, for example, from about 30° to about 60°, typically about 45° to the horizontal.

In order that the invention may be clearly understood and readily carried into effect, a preferred embodiment thereof will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which :—

Figure 1 is a vertical section through an oil-water separator constructed according to the invention; and

Figure 2 is a vertical section on an enlarged scale on the line A—A of Figure 1.

Referring to the drawings, and to Figure 1 in particular, an oil-water separator comprises a rectangular plan vessel 1 to which an oil-in-water dispersion to be separated is fed by way of line 2. This dispersion may include only "primary dispersion" sized droplets of oil or may also include a proportion of "secondary dispersion" sized oil droplets. It may also contain a minor amount of solids. Disengaged oil overflows a weir 3, the height of which is adjustable, and exits the separator by way of line 4. Disengaged water overflows weir 5 and exits the separator by way of line 6.

Vessel 1 contains a pack of lamellar bodies 7, which is illustrated in more detail in Figure 2, as well as a coalescer pad 8 which is made, for example, of a knitted mesh fabric. Coalescer pads of suitable type can be obtained from KnitMesh Limited, of Sanderstead Station Approach, South Croydon, Surrey. A particularly suitable form of pad is that described in United States Patent Specification No. 4057493 and sold under the trademark "KnitMesh DC".

As can be seen from Figure 2 pack 7 comprises four layers 9, 10, 11 and 12 of plates. Within each layer 9, 10, 11 or 12 the individual plates 13 are aligned parallel to the walls 14, 15 so that they are generally aligned with the direction of flow of liquid through the vessel 1. The plates 13 are arranged parallel to one another within each layer and are spaced uniformly one from another. As can readily been seen from Figure 2, the plates 13 within each layer are inclined transverse to the flow of liquid at an angle of about 45° to the horizontal.

As the oil-in-water dispersion passes through pack 7 between a pair of plates 13 the "primary dispersion" sized oil droplets rise through the water layer until they contact the underside of the upper one of the pair of plates 13 where they coalesce with oil from other droplets and form a layer of oil which flows up towards a lip 16. This lip 16 is melted or formed onto the upper edge of each plate 13 and runs along the length of each plate 13 in the direction of flow of the continuous phase, i.e. water. If desired, lip 16 can be indented at intervals along its length in order to promote collection drip point release locations.

As is well known, the rate at which a "primary dispersion" sized oil droplet rises through the water layer depends upon the density difference between the oil and water and upon the diameter of the oil droplet, as well as, to a lesser extent, upon the temperature. In designing the illustrated coalescer all these factors should be taken into account so as to ensure that the length of the plates 13 of the pack 7, as measured in the direction of flow of the aqueous phase, is sufficient in relation to the maximum flow rate of dispersion to the coalescer and to the spacing between adjacent pairs of plates 13 to allow time for all such oil droplets present in the dispersion at the inlet end of the pack 7 to rise and coalesce with already disengaged oil on the underside of the relevant plate 13 before being carried out of the exit end of pack 7. Generally speaking the closer the plates 13 in each layer are positioned, the shorter can be the length of the plates 13 for a given dispersion measured in the direction of flow since the "primary dispersion" sized oil droplets have a shorter distance to rise before encountering the underside of a plate 13 of an oil layer thereon; hence the closer the plates 13 are, the more compact the design can be. However the closer the plates 13 are spaced the greater the pressure drop across pack 7 and the greater the danger of blockage due to solids accumulating between the plates 13. Thus the spacing between plates 13 will usually be selected so as to minimise the danger of blockage.

As can be seen from Figure 2, the plates 13 of layers 9 and 11 are inclined in the opposite transverse direction to the plates 13 of layers 10 and 12. Moreover the lips 16 on each plate 13 of the lower layers 10, 11 and 12 are positioned intermediate corresponding lips 17 which are attached along the lower edges of plates 13 of the layer (9, 10, or 11 as the case may be) immediately above them. Lips 16 serve to release disengaged oil flowing up the underside of the respective plate 13 and allow it to flow up without redispersion to the underside of the corresponding plate 13 in the layer immediately above it, until finally it coalesces with a layer of disengaged oil that floats on the surface of the liquid in the vessel 1 and overflows weir 3.

Immediately downstream from pack 7 is mounted coalescer pad 8. This serves to coalesce some of the smaller oil droplets that are not disengaged from the dispersion in passage through pack 7. Because the plates 13 of pack 7 are aligned with the overall direction of liquid flow there is no need to introduce a level control compartment between pack 7 and coalescer 8 as is necessary in conventional inclined plate separators. Hence the illustrated oil-water separator can be made to a more compact design than can a conventional inclined plate separator fitted with a coalescer pad. Vessel 1 is fitted in addition with outlets 18, 19 for solids that may settle out

Although vessel 1 has been illustrated as being an open-topped rectangular tank it will be appreciated by those skilled in the art that the invention can be adapted to closed vessels of various shapes, e.g. cylindrical vessels with substantially axial flow of liquid therethrough. Moreover such closed vessels can be operated under reduced or elevated pressures, as desired.

Instead of using a coalescer pad 8 as a second coalescer it is alternatively contemplated to use dissolved and/or dispersed air flotation by introducing air into the liquid adjacent the exit end of pack 7 via a water stream distributor sited above the sludge zone.

Although the illustrated oil-water separator has been described in relation to separation of an oil-in-water type dispersion, it is equally suited to separation of water-in-oil type dispersions. Moreover it can also be used to treat three phase dimensions, such as oil/gas/water dispersions or oil/water/sand dispersions found at the wellhead in oil or gas fields. The invention can also be used in liquid-liquid extraction processes, e.g. for separating the phase mixtures formed in so-called solvent extraction of metal such a zinc, copper or uranium using hydrophobic solutions or organic-soluble metal chelating agents to extract metals from aqueous solutions thereof.

The invention can also be used to separate gas/liquid/liquid phases such as are found downstream of reactors in a large variety of chemical process plant.

CLAIMS

1. A phase separation device for separating the phases of a phase mixture containing at least two phases, which device comprises a vessel containing at least one pack of lamellar bodies through which phase mixture is passed in use, the or each pack comprising a plurality of layers of lamellar bodies arranged one above the other in the path of the flow of the phase mixture and each layer comprising a plurality of lamellar bodies arranged substantially parallel to one another and inclined transverse to and substantially aligned with the direction of flow of the phase.

2. A device according to claim 1, in which the direction of flow of the phase mixture is at an angle of at most not more than about 15° to the horizontal.

3. A device according to Claim 1 or Claim 2, in which the direction of flow of phase mixture is substantially horizontal.

4. A device according to any one of claims 1 to 3, further including a coalescer means downstream from the pack or packs of lamellar bodies.

5. A device according to claim 4, in which the coalescer means comprises a pad of knitted mesh fabric.

6. A device according to any one of claims 1 to 5, in which the lamellar bodies are uniformly spaced one from another within each layer and/or pack.

7. A device according to any one of claims 1 to 6, in which the upper edges of the lamellar bodies of one layer lie intermediate to the lower edges of the lamellar bodies of the layer immediately above the first mentioned layer and the plates of adjacent layers are inclined in opposite transverse directions.

8. A device according to any one of claims 1 to 7, in which the angle between the plane of each lamellar body of a respective layer and a vertical plane, measured in a plane at right angles to the direction of flow, ranges from about 30° to about 60°.

9. A device according to claim 8, in which the said angle is about 45°.

10. A device according to claim 8 or claim 9, in which the direction of flow is horizontal and the lamellar bodies are inclined at an angle to the horizontal of from about 30° to about 60°.

11. A device according to claim 10, in which the lamellar bodies are inclined at an angle of about 45° to the horizontal.

12. A phase separation device constructed and arranged substantially as herein described with particular reference to the drawings.

13. A process for separating the phases of a phase mixture containing at least two phases, which comprises passing the mixture through a vessel containing at least one pack of lamellar bodies, the or each pack comprising a plurality of layers of lamellar bodies arranged one above the other in the path of flow of the phase mixture and each layer comprising a plurality of lamellar bodies arranged substantially parallel to one another and inclined transverse to and substantially aligned with the direction of flow of the phase mixture, and recovering at least one separated phase from the downstream end of the vessel.

14. A process according to claims 13, in which the direction of flow is at an angle of at most not more than about 15° to the horizontal.

15. A process according to claim 14, in which the direction of flow of the phase mixture is substantially horizontal.

16. A process according to any one of claims 13 to 15, in which the phase mixture comprises an oil-in-water or water-in-oil type dispersion.

17. A process according to claim 16, in which a coalescer means is positioned downstream from the pack or packs of lamellar bodies in the path of dispersion.

18. A process according to any one of claims 13 to 17, in which the lamellar bodies are uniformly spaced one from another within each layer and/or pack.

19. A process according to any one of claims 13 to 18, in which the upper edges of the lamellar bodies of one layer lie intermediate to the lower edges of the lamellar bodies of the layer immediately above the first mentioned layer and the plates of adjacent layers are inclined in opposite transverse directions.

20. A process according to any one of claims 13 to 19, in which the angle between the plane of each lamellar body of a respective layer and a vertical plane, measured in a plane at right angles to the direction of flow, ranges from about 30° to about 60°.

21. A process according to claim 20, in which the said angle is about 45°.

22. A process according to claim 20 or claim 21, in which the direction of flow is horizontal and the lamellar bodies are inclined at an angle to the horizontal of from about 30° to about 60°.

23. A process according to claim 22, in which the lamellar bodies are inclined at an angle of about 45° to the horizontal.

24. A process for separating the phases of a phase mixture containing at least two phases conducted substantially as herein described with particular reference to the drawings.

25. Each and every novel feature and combination of features herein disclosed and their obvious equivalents.

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